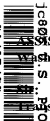


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Transmitted herewith for filing is the Patent Application of:

Inventor(s): Simon Antony James Holdsworth, Stephen James Paul Todd, Malcolm David Ayres,
Timothy Nicholas Holloway, Marc-Thomas Schmidt, Michael George Taylor

For: PUBLISH/SUBSCRIBE DATA PROCESSING WITH PUBLICATION POINTS FOR CUSTOMISED
MESSAGE PROCESSING

Enclosed are:

- ☒ Patent Specification and Declaration
- ☒ 3 sheets of drawing(s)
- ☒ An assignment of the invention to International Business Machines Corporation (includes Recordation Form Cover Sheet)
- ☒ A certified copy of a United Kingdom application filed on September 28, 1999, Serial Number 9922802.5
- ☒ Information Disclosure Statement, PTO 1449 and copies of references

The fee has been calculated as shown below:

For	Number Filed	Number Extra	Rate	Fee \$
Basic Fee				\$ 690.00
Total Claims	8 - 20		x 18 =	
Independent Claims	3 - 3		x 78 =	
MULTIPLE DEPENDENT CLAIM PRESENTED			260 =	
TOTAL				690.00

☒ Please charge my Deposit Account No. 09-0461 in the amount of \$690.00. A duplicate copy of this sheet is enclosed.

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Person mailing paper/fee Dianne Lane

Signature Dianne Lane

Respectfully submitted

Jeanine S. Ray-Tarletts
Registration No. 39,808
IBM Corp, IP Law Dept T81/B062,
3039 Cornwallis Road,
PO Box 12195,
Research Triangle Park, NC 27709-2195.

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PUBLISH/SUBSCRIBE DATA PROCESSING WITH
PUBLICATION POINTS FOR CUSTOMISED MESSAGE PROCESSING

5 Cross Reference to Related Applications

 The present application is related to USSSN
09/510,465 filed February 22, 2000, titled
"Publish/subscribe Data Processing with Subscription
10 Points for Customised Message Processing", commonly
assigned with the present invention.

Field of the Invention

 The present invention relates to the field of data
processing and more specifically to event notification
data processing which distributes event messages from
suppliers (called, hereinafter, "publishers") of data
messages to consumers (called, hereinafter "subscribers")
15 of such messages. While there are many different types
of known event notification systems, the subsequent
discussion will describe the publish/subscribe event
notification system as it is one of the most common.

25 Background of the Invention

 Publish/subscribe data processing systems (and event
notification systems in general) have become very popular

in recent years as a way of distributing data messages (events) from publishing computers to subscribing computers. The increasing popularity of the Internet, which has connected a wide variety of computers all over the world, has helped to make such publish/subscribe systems even more popular. Using the Internet, a World Wide Web browser application (the term "application" or "process" refers to a software program, or portion thereof, running on a computer) can be used in conjunction with the publisher or subscriber in order to graphically display messages. Such systems are especially useful where data supplied by a publisher is constantly changing and a large number of subscribers needs to be quickly updated with the latest data. Perhaps the best example of where this is useful is in the distribution of stock market data.

In such systems, publisher applications of data messages do not need to know the identity or location of the subscriber applications which will receive the messages. The publishers need only connect to a publish/subscribe distribution agent process, which is included in a group of such processes making up a broker network, and send messages to the distribution agent process, specifying the subject of the message to the distribution agent process. The distribution agent process then distributes the published messages to subscriber applications which have previously indicated

to the broker network that they would like to receive data messages on particular subjects. Thus, the subscribers also do not need to know the identity or location of the publishers. The subscribers need only
5 connect to a distribution agent process.

One such publish/subscribe system which is currently in use, and which has been developed by the Transarc Corp. (a wholly owned subsidiary of the assignee of the present patent application, IBM Corp.) is shown in Fig. 1. Publishers 11 and 12 connect to the publish/subscribe broker network 2 and send published messages to broker network 2 which distributes the messages to subscribers 31, 32, 33, 34. Publishers 11 and 12, which are data
10 processing applications which output data messages, connect to broker network 2 using the well known inter-application data connection protocol known as remote procedure call (or RPC) (other well known protocols, such as asynchronous message queuing
15 protocols, can also be used). Each publisher application could be running on a separate machine, alternatively, a single machine could be running a plurality of publisher applications. The broker network 2 is made up of a plurality of distribution agents (21 through 27) which
20 are connected in a hierarchical fashion which will be described below as a "tree structure". These distribution agents, each of which could be running on a separate machine, are data processing applications which
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distribute data messages through the broker network 2 from publishers to subscribers. Subscriber applications 31, 32, 33 and 34 connect to the broker network 2 via RPC in order to receive published messages.

5

Publishers 11 and 12 first connect via RPC directly to a root distribution agent 21 which in turn connects via RPC to second level distribution agents 22 and 23 which in turn connect via RPC to third level distribution agents 24, 25, 26 and 27 (also known as "leaf distribution agents" since they are the final distribution agents in the tree structure). Each distribution agent could be running on its own machine, or alternatively, groups of distribution agents could be running on the same machine. The leaf distribution agents connect via RPC to subscriber applications 31 through 34, each of which could be running on its own machine.

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In order to allow the broker network 2 to determine which published messages should be sent to which subscribers, publishers provide the root distribution agent 21 with the name of a distribution stream for each published message. A distribution stream (called hereinafter a "stream") is an ordered sequence of messages having a name (e.g., "stock" for a stream of stock market quotes) to distinguish the stream from other streams (this is known as "topic based"

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publish/subscribe, another well known model is called "content based publish/subscribe which involves matching publishers and subscribers by the content of the messages rather than by the topic). Likewise, subscribers provide the leaf distribution agents 31 through 34 with the name of the streams to which they would like to subscribe. In this way, the broker network 2 keeps track of which subscribers are interested in which streams so that when publishers publish messages to such streams, the messages can be distributed to the corresponding subscribers. Subscribers are also allowed to provide filter expressions to the broker network in order to limit the messages which will be received on a particular stream (e.g., a subscriber 31 interested in only IBM stock quotes could subscribe to the stream "stock" by making an RPC call to leaf distribution agent 24 and include a filter expression stating that only messages on the "stock" stream relating to IBM stock should be sent to subscriber 31).

The above-described publish/subscribe architecture provides the advantage of central co-ordination of all published messages, since all publishers must connect to the same distribution agent (the root) in order to publish a message to the broker network. For example, total ordering of published messages throughout the broker network is greatly facilitated, since the root can easily assign sequence numbers to each published message

on a stream. However, this architecture also has the disadvantage of publisher inflexibility, since each publisher is constrained to publishing from the single root distribution agent, even when it would be much easier for a publisher to connect to a closer distribution agent.

In the Fig. 1, a publisher application 11, running on one computer, is, for example, a supplier of live stock market data quotes. That is, publisher application 11 provides frequent messages stating the present value of share prices. In this example, publisher application 11 is publishing messages on a stream called "stock" which has already been configured in the broker network 2. As is well known, when publisher 11 wishes to publish a stock quote message to stream "stock", publisher 11 makes an RPC call to the root distribution agent 11 which is at the top level of the broker network tree structure. In this example, subscriber application 32, running on another computer, has sent a subscription request via an RPC call to leaf distribution agent 24, which is at the bottom level of the tree structure, indicating that subscriber 32 would like to subscribe to stream "stock".

Thus, whenever publisher 11 publishes a data message to stream "stock" the distribution tree structure of broker network 2 channels the message down through the root distribution agent 21, through any intermediary

distribution agents (e.g., 22 in the example of Fig. 1) and through the leaf distribution agent 24 to the subscriber 32. This involves a series of RPC calls being made between each successive circle in the diagram of Fig. 1 connecting publisher 11 and subscriber 32 (i.e., 11 to 21, 21 to 22, 22 to 24 and 24 to 32).

Figure 2 shows a different publish/subscribe architecture where publisher applications can publish messages to the broker network by directly communicating with any one of a plurality of distribution agents (brokers). For example, publisher application 201 is shown communicating directly with Broker 12. There is no requirement in this architecture that all publisher applications communicate directly with a top (or root) distribution agent. Publisher application 201 can potentially communicate directly with any of the distribution agents shown in Fig 2, in the described examples below it will be shown communicating directly with Broker 12.

Subscriber applications 202 and 203 would like to receive messages on the stream/topic that publisher application 201 is publishing on. Thus, subscriber applications 202 and 203 communicate directly with Brokers 1112 and 1221, respectively, to provide subscription data thereto informing the broker hierarchy of their desire to receive such published messages.

Since the publisher application 201 is allowed to communicate directly with any of a plurality of distribution agents, the subscription data entered by the subscriber applications must be propagated throughout the broker network to each Broker shown in Fig. 2. This way, no matter which distribution agent the publisher application 201 happens to communicate directly with, the published messages will be able to be routed to the subscriber applications 202 and 203.

Publish/subscribe broker systems have commonly been integrated into multi-function message broker systems which are used to inter-connect applications which may be on heterogeneous platforms and may use different message formats. For example, Saga Software of Reston, Virginia (USA) (www.sagasoftware.com) have such a message broker product called "Sagavista" (a trademark of Saga Software). Further, Tibco Software Inc. of Palo Alto, California (USA) (www.tibco.com) also have such a message broker called "TIB/Message Broker" (both "TIB" and "TIB/Message Broker" are trademarks of Tibco). In these multi-function message brokers, a set of pluggable data processing nodes is provided, with each node being dedicated to a specific data processing task, such as message format transformation, publish/subscribe message distribution, and a rules engine for deciding (based on a plurality of predefined rules) where an incoming message should be routed.

In these multi-function message broker products, when a subscriber application registers a subscription request with the broker, the subscriber application sends the subscription request to a publish/subscribe broker node specifying the topic of the desired subscription. The publish/subscribe broker node (usually in cooperation with a plurality of other such publish/subscribe broker nodes) then ensures that any published messages on that topic are sent to the subscriber application. Different subscribers may wish to receive the same published messages but in different message formats (or may desire that some other type of processing be carried out on published messages before such messages are delivered to the subscriber). For example, a subscriber in the United States may want to know IBM's stock price per share in US dollars while another subscriber in the United Kingdom may want to know IBM's stock price in UK (British) pounds.

In order to accommodate such format desires of various subscribers, the message broker would have to modify the topic after having performed a format transformation so that a subscriber can subscribe to this modified topic (rather than the original topic that the publisher published on) in order to receive the format-transformed messages. Alternatively, the publishers would have to publish the same messages in different formats (with each format having its own

topic), thus doing away with the need for the broker to do the format transformation. Because the topic needs to correspond to the format in both of these cases, this can cause many problems. For example, it is very useful to carry out access control on a topic basis. That is, when deciding which subscribers can have access to which published messages, it is very useful to be able to use the topics of the messages to make such access control decisions. However, when the topics must be different for essentially the same group of messages because of format changes, such access control decisions become much more complex.

It would be clearly desirable to be able to use the same topic for a variety of different message formats in a message broker, but the present state of the art does not allow for this.

Summary of the Invention

According to one aspect, the present invention provides a message broker data processing apparatus including: message broker data processing apparatus comprising: means for receiving published messages on a topic from a plurality of publisher applications; means for processing the received messages; and means for distributing the processed messages to a subscriber application; wherein the means for receiving includes a

plurality of publication point data processing nodes, each of which receives published messages on said topic from a publisher application.

5 According to a second aspect, the present invention provides a data processing method of carrying out the functionality discussed above with respect to the first aspect.

10 According to a third aspect, the present invention provides a computer readable storage medium having a computer program stored on it which, when executed on a computer, carries out the functionality of data processing method of the second aspect of the invention.

15 Thus, the present invention provides a message broker having a publish/subscribe capability where a publisher application can publish messages in a manner which is most convenient to that publisher application, and a subscriber application will receive such published messages after the messages have undergone specific data processing, all without the need for the topic names used by the publisher application, broker and subscriber application to be modified. For example, the publisher,
20 broker and subscriber can use the same topic name even though the messages sent under this topic will be of differing formats. The presence of multiple publication
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points, selectable by a particular publisher application, within the broker provides for this ability.

As one advantage of the invention, access control
5 can thus be easily carried out using the topic name.
Further, the publisher application does not need to
publish the same messages on a plurality of topics in
order to accommodate subscribers who want publications in
differing formats, thus decoupling the publisher
10 application from having to deal with the varying desires
of subscribers. The publisher need only publish messages
in the format most convenient to that publisher.

Brief Description of the Drawings

15 The invention will be better understood by referring
to the detailed description of the preferred embodiments
which will now be described in conjunction with the
following drawing figures:

20 Figure 1 is a block diagram showing a first
architecture of a publish/subscribe data processing
system to which the preferred embodiment of the present
invention can be advantageously applied;

25 Figure 2 is a block diagram showing a second
architecture of a publish/subscribe data processing

system to which the preferred embodiment of the present invention can be advantageously applied; and

Fig. 3 is a block diagram showing an exemplary message broker according to a preferred embodiment of the present invention.

Detailed Description of the Preferred Embodiments

In Fig. 3 a message broker 32 receives published messages on a topic called "IBM stock" from a publisher application 31a (which is an application running at a major stock exchange in the United States of America) and distributes such published messages to subscriber application 33 (which is a stock broking agency also located in the United States of America) which has previously registered a subscription to the topic "IBM stock". Message broker 32 also receives published messages on the topic "IBM stock" from another publisher application 31b (which is an application running at a major stock exchange in the United Kingdom) and distributes such published messages to subscriber application 33 (again, which is a stock broking agency located in the United States of America) which has previously registered a subscription to the topic "IBM stock". In this example, the publisher application, broker and subscriber applications are all running on separate machines (and are thus interconnected via a

network which is not shown in Fig. 3). In other embodiments, however, two or more of the applications (e.g., the publisher and the broker) could be running on the same machine. Further, as was explained above, the broker 32 is most likely running on a plurality of machines.

When one of the publisher applications 31a or 31b communicates with the broker 32 in order to publish messages thereto, the publisher application specifies a particular publication point (e.g., 323 or 324) as the point of entry into the message broker 32. A publication point data processing node (or "publication point" for short) is a data processing node which acts as a point of entry for published messages in a messageflow of data processing nodes making up a message broker. That is, each publication point is at the beginning of a specific data processing path through the broker. A publisher application selects a publication point depending on which particular desired path the published messages should take depending on the nature of the published messages and the nature of the processing that will be carried out on that path.

For example, publisher application 31b selects publication point 324 because publisher application 31b is located in the United Kingdom and thus publisher application 31b "knows" that a message transformation

will be needed. Specifically, once the publisher application 31b's published messages pass through the publication point 324, they are passed to message transformation data processing node 321 which performs the function of transforming the format of the published messages so that the IBM stock prices, which are originally published in UK pounds by publisher application 31b, are converted to US dollars. The message transformation node 321 accesses local storage 322 in order to determine the current exchange rate of UK pounds to US dollars (this exchange rate is updated at the beginning of every business day). After having their UK pound amounts converted to US dollars, the messages are output from the message transformation node 321 and received at a subscription point processing node 325.

A subscription point data processing node (or "subscription point" for short) is an instance of a publish/subscribe matching engine which performs the function of looking at the topics in previously received subscription requests (received from subscribers) and determining whether the topic in an incoming message (just received from a publisher application) matches the topic of any of the previously received subscription requests. For any subscriptions that match, the subscription point data processing node distributes the published message to the subscriber application(s) which had entered the subscription requests.

Back to Fig. 3, the subscription point processing node 325 determines (e.g., by accessing local storage 322) that subscriber application 33 has previously entered a subscription on the topic "IBM stock". Thus, subscription point processing node 325 distributes the published messages to subscriber application 33.

On the other hand, publisher application 31a communicates with the broker 32 via another publication point 323, and thus published messages from publisher 31a take another path through the broker bypassing the message transformation data processing node 321. Specifically, the published messages from publisher 31a are sent directly to subscription point data processing node 325. Publisher application 31a chooses to communicate with publication point 323 because publisher application 31a is located in the United States and thus the published messages are already in the US dollars format, and thus there is no need to transform the messages to the US dollars format, which is the format required by the subscriber application 33. Subscription point data processing node 325 then performs a publish/subscribe topic matching operation and determines that subscriber application 33 has previously entered a subscription request to the topic "IBM stock". Thus, subscription point processing node 325 distributes the published messages to subscriber application 33.

Thus, by the use of a plurality (two in Fig. 3) of publication point data processing nodes in a message broker, publisher applications can select amongst the plurality of publication points in order to publish messages which will be received by subscribers in a message format selected by the subscriber without having to use different topics (the topic "IBM stock" is the same for both publication points 323 and 324 and for both publisher applications 31a and 31b). This allows access control to be easily carried out on a topic basis. For example, the broker can perform a security measure on both publisher applications 31a and 31b by simply checking whether the requested topic "IBM stock" of their published messages is a topic which has previously been determined as acceptable for publishers 31a and 31b from a security standpoint.

In a multi-broker environment the subscription point at each of several brokers is connected to the subscription point at other brokers exactly as described for simple publish/subscribe systems. The message is published to a publication point at an initial receiving broker (IRB). Broker IRB process the message according to the publication point on which it was published. The processing in broker IRB may cause the message (or one or more derivations of the message) to reach the subscription point at broker IRB. Once a message (original or derivative) reaches the subscription point

at broker IRB it is made available to subscribers on other brokers using standard interbroker publish/subscribe technology. This mechanism of this inter broker publish/subscribe technology operates independently from the mechanism by which the message reaches the subscription point at broker IRB.

The use of publication points in message flows through the broker is not limited to knowledge of a downstream message format transformation. Such publication points could be used in a wide variety of different contexts.

CLAIMS

1. A message broker data processing apparatus
5 comprising:

means for receiving published messages on a topic
from a plurality of publisher applications;

10 means for processing the received messages; and

means for distributing the processed messages to a
subscriber application;

15 wherein the means for receiving includes a plurality
of publication point data processing nodes, each of which
receives published messages on said topic from a
publisher application.

20 2. The apparatus of claim 1 wherein said apparatus
communicates with a subscriber application over the
Internet and wherein at least one of the subscriber
applications and the publisher application runs in
conjunction with a World Wide Web browser.

25 3. The apparatus of claim 1 wherein the broker performs
different processing on published messages according to

the publication point on which said published messages are published.

4. The apparatus of claim 3 wherein messages in different formats are published on different publication points, and the processing associated with each publication point is used to render the messages into a standard format available at a subscription point.

5. A message broker data processing method comprising steps of:

receiving published messages on a topic from a plurality of publisher applications;

processing the received messages; and

distributing the processed messages to a subscriber application;

wherein the receiving step is carried out via a plurality of publication point data processing nodes, each of which receives messages on said topic from a publisher application.

6. The method of claim 5 wherein the broker performs different processing on published messages according to

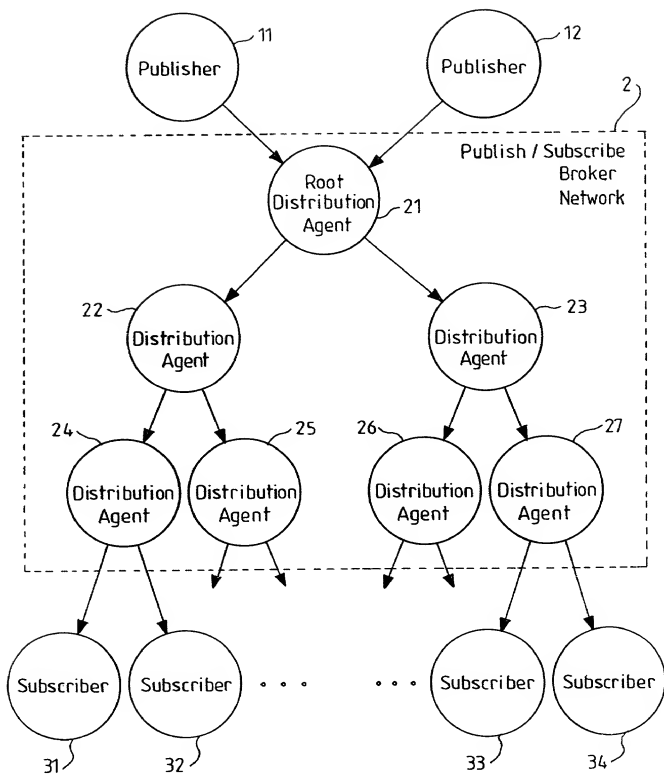
the publication point on which said published messages are published.

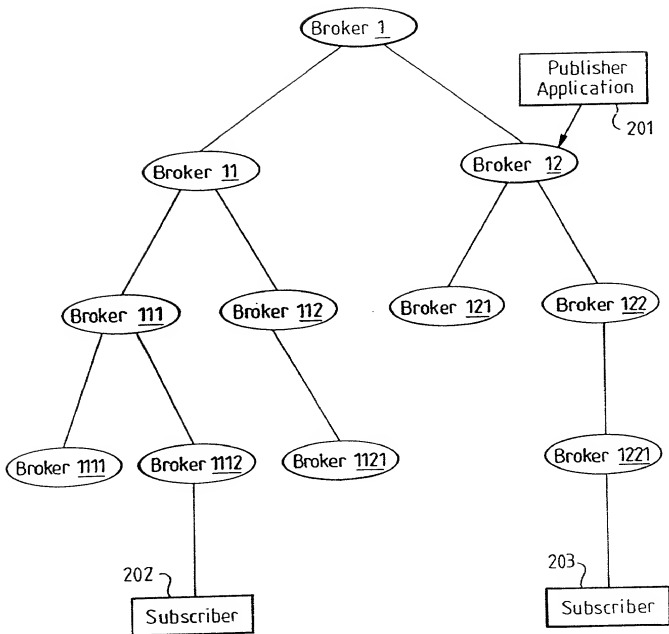
7. The method of claim 6 wherein messages in different
5 formats are published on different publication points,
and the processing associated with each publication point
is used to render the messages into a standard format
available at a subscription point.

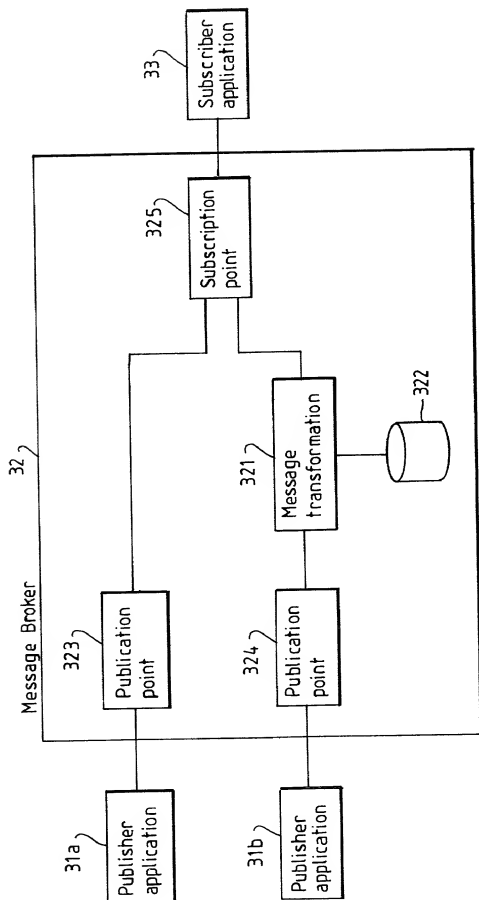
10 8. A computer program product stored on a computer
readable storage medium for, when run on a computer,
instructing the computer to carry out the method steps
recited in claim 5.

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FIG. 1

FIG. 2

FIG. 3

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name; I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

PUBLISH/SUBSCRIBE DATA PROCESSING WITH PUBLICATION POINTS FOR CUSTOMISED MESSAGE PROCESSING

the specification of which (check one)

X is attached hereto.

_____ was filed on
as Application Serial No.
and was amended on

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, CFR 1.56.

I hereby claim foreign priority benefits under Title 35, USC 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s):

9922802.5	United Kingdom	28 September 1999	<u> X </u> Yes <u> </u> No
Number	Country	Filing Date	Priority Claimed
		Day/Month/Year	

I hereby claim the benefit under Title 35, USC 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, USC 112, I acknowledge the duty to disclose information material to the patentability of this application as defined in Title 37, CFR 1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

Prior U.S. Applications:

Serial No.	Filing Date	Status
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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorneys and/or agents to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:

Edward H. Duffield, Reg. No. 25,970; A. Bruce Clay, Reg. No. 32,121; Gregory M. Doudnikoff, Reg. No. 32,847; Jeanine S. Ray-Yarletts, Reg. No. 39,808; Jerry W. Herndon, Reg. No. 27,901, Kevin J. Fournier, Reg. No. 34,333

Send all correspondence to:

Jeanine S. Ray-Yarletts
IBM Corp, IP Law Dept T81/B062,
3039 Cornwallis Road,
PO Box 12195,
Research Triangle Park, NC 27709-2195.

FULL NAME OF SOLE OR FIRST INVENTOR:

Simon Antony James Holdsworth

INVENTOR'S SIGNATURE:



DATE: 5 April 2000

RESIDENCE:

4 Hillbury Avenue, Andover, Hampshire SP10 2LZ, UK

CITIZENSHIP:

British

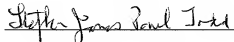
POST OFFICE ADDRESS:

As above

FULL NAME OF SECOND INVENTOR:

Stephen James Paul Todd

INVENTOR'S SIGNATURE:



DATE: 6 April 2000

RESIDENCE:

10 Christchurch Road, Winchester, Hampshire SO23 9SR, UK

CITIZENSHIP:

British

POST OFFICE ADDRESS:

As above

FULL NAME OF THIRD INVENTOR:

Malcolm David Ayres

INVENTOR'S SIGNATURE:



DATE: 5th April 2000

RESIDENCE:

Parbrook, The Square, Braishfield, Romsey, Hampshire
SO51 0PQ, UK

CITIZENSHIP:

British

POST OFFICE ADDRESS:

As above

FULL NAME OF FOURTH INVENTOR:

Timothy Nicholas Holloway

INVENTOR'S SIGNATURE: Timothy Nicholas Holloway DATE: 6th April 2000
RESIDENCE: Wood End, Pikes Hill Avenue, Lyndhurst, Hampshire
SO43 7AX, UK
CITIZENSHIP: British
POST OFFICE ADDRESS: As above

FULL NAME OF FIFTH INVENTOR:

Marc-Thomas Schmidt

INVENTOR'S SIGNATURE: Marc-Thomas Schmidt DATE: 6th April 2000
RESIDENCE: 4 The Close, Kiln Lane, Eastleigh, Hampshire SO50 6HT, UK
CITIZENSHIP: German
POST OFFICE ADDRESS: As above

FULL NAME OF SIXTH INVENTOR:

Michael George Taylor

INVENTOR'S SIGNATURE: Michael George Taylor DATE: 5/4/00
RESIDENCE: St Elmo, Duncan Road, Park Gate, Southampton, Hampshire
SO31 1BD, UK
CITIZENSHIP: British
POST OFFICE ADDRESS: As above